

What is Claimed:

- 1 1. An apparatus for delivering water vapor to a gas comprising:
 - 2 a plurality of hollow fiber membranes each defining a passage for the
 - 3 flow of gas from an upstream end of said passage to a downstream end of said
 - 4 passage;
 - 5 an enclosure enclosing said hollow fiber membranes, said enclosure
 - 6 having an air inlet positioned to direct air to said upstream end of each of said
 - 7 passages of said hollow fiber membranes and an air outlet positioned to direct air
 - 8 from said downstream end of each of said passages of said hollow fiber membranes,
 - 9 said enclosure also having a water inlet positioned to direct water toward outer
 - 10 surfaces of said hollow fiber membranes and a water outlet positioned to direct water
 - 11 from said enclosure; and
 - 12 said hollow fiber membranes having a combined surface area in the
 - 13 range of about 90 square centimeters to about 110 square centimeters.
- 1 2. The apparatus of claim 1 wherein said hollow fiber membranes
 - 2 are configured to resist water breakthrough for at least one hour when gas flow is
 - 3 absent and the static water pressure is about 47 mmHg.
- 1 3. The apparatus of claim 1 wherein said hollow fiber membranes
 - 2 are configured such that a water flux after an initial water breakthrough does not
 - 3 exceed about 0.21 milliliters per minute at a static water pressure of 47 mmHg.

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5 4. A method for heating and humidifying a gas comprising the
6 steps of:

7 (a) delivering gas through a plurality of hollow fiber membranes at a
8 flow rate of about 1 liter per minute to about 8 liters per minute;

9 (b) contacting outer surfaces of the hollow fiber membranes with water
10 at a temperature of about 33°C to about 43°C; and

11 (c) maintaining the combined surface area of the hollow fiber
12 membranes between about 90 square centimeters and about 110 square
13 centimeters.

1 5. The method of claim 4 further comprising the step of providing
2 the gas with a relative humidity at about 80% to about 100%.

1 6. The method of claim 4 further comprising the step of providing
2 the gas with a relative humidity of about 95% at 5 liters per minute.

1 7. The method of claim 4 further comprising the step of
2 maintaining a pressure drop through the hollow fiber membranes less than about
3 100 mmHg at 5 liters per minute.

1 8. A system for delivering humidified gas to a patient, said system
2 comprising:

3 means for receiving water;

4 means for receiving gas; and

5 an apparatus in flow communication with said water receiving means
6 and said gas receiving means, said apparatus being configured to deliver vapor form
7 water to gas, said apparatus comprising:

8 a plurality of hollow fiber membranes each defining a passage
9 for the flow of gas from an upstream end of said passage to a downstream
10 end of said passage;

11 an enclosure enclosing said hollow fiber membranes, said
12 enclosure having an air inlet positioned to direct air to said upstream end of
13 each of said passages of said hollow fiber membranes and an air outlet
14 positioned to direct air from said downstream end of each of said passages of
15 said hollow fiber membranes, said enclosure also having a water inlet
16 positioned to direct water toward outer surfaces of said hollow fiber
17 membranes and a water outlet positioned to direct water from said enclosure;
18 and

19 said hollow fiber membranes having a combined surface area in the
20 range of about 90 square centimeters to about 110 square centimeters.

1 9. The system of claim 8 wherein each of said hollow fiber
2 membranes is configured to resist water breakthrough for at least one hour when gas
3 flow is absent and the static water pressure is about 47 mmHg.

1 10. The system of claim 8 wherein each of said hollow fiber
2 membranes is configured such that a water flux after an initial water breakthrough
3 does not exceed about 0.21 milliliters per minute at a static water pressure of 47
4 mmHg.

1 11. The system of claim 8, said water receiving means comprising a
2 conduit couplable to a source of water.

1 12. The system of claim 8, said gas receiving means comprising a
2 conduit couplable to a source of gas.

1 13. An apparatus for delivering water vapor to a gas comprising:

2 a plurality of hollow fiber membranes each defining a passage for the
3 flow of gas from an upstream end of said passage to a downstream end of said
4 passage; and

5 an enclosure enclosing said hollow fiber membranes, said enclosure
6 having an air inlet positioned to direct air to said upstream end of each of said
7 passages of said hollow fiber membranes and an air outlet positioned to direct air
8 from said downstream end of each of said passages of said hollow fiber membranes,
9 said enclosure also having a water inlet positioned to direct water toward outer
10 surfaces of said hollow fiber membranes and a water outlet positioned to direct water
11 from said enclosure;

12 wherein said hollow fiber membranes are configured to resist water
13 breakthrough for at least one hour when gas flow is absent and the static water
14 pressure is about 47 mmHg; and

15 wherein said hollow fiber membranes are configured such that a water
16 flux after an initial water breakthrough does not exceed about 0.21 milliliters per
17 minute at a static water pressure of 47 mmHg.

18 14. The apparatus of claim 13 wherein said hollow fiber membranes
19 have a combined surface area in the range of about 90 square centimeters to about
20 110 square centimeters.

21 15. The apparatus of claim 14 wherein said hollow fiber membranes
22 have a combined surface area of about 100 square centimeters.